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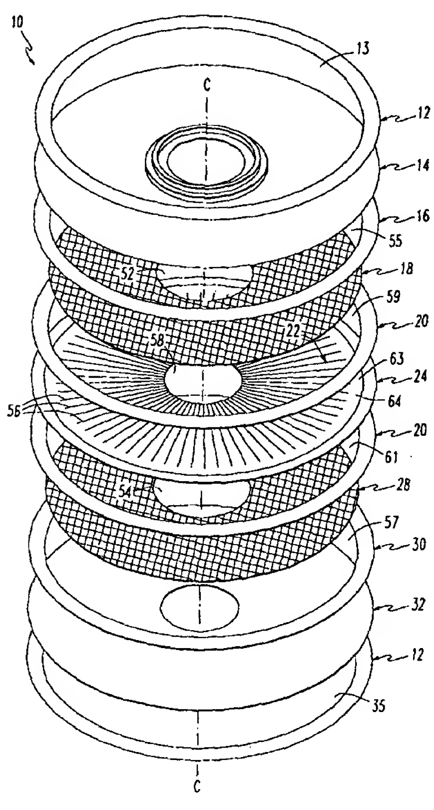
(54) Title: FLUID SEPARATION ASSEMBLY



(57) Abstract: A fluid separation assembly (10) having a fluid permeable membrane (38, 62) and a wire mesh membrane (18 and 28) adjacent the fluid permeable membrane (38 and 62), wherein the wire mesh membrane (18 and 28) supports the fluid permeable membrane (38 and 62) and is coated with an intermetallic diffusion barrier. The barrier may be a thin film containing at least one of a nitride, oxide, boride, silicide, carbide and aluminide. Several fluid separation assemblies (10) can be used in a module (85) to separate hydrogen from a gas mixture containing hydrogen.

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FLUID SEPARATION ASSEMBLY

CROSS REFERENCE TO RELATED APPLICATIONS

Not Applicable.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not Applicable.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to apparatuses and methods for separation of a desired fluid from a fluid mixture. More particularly, the present invention is generally directed to a fluid separation assembly having a membrane permeable to a desired fluid and a wire mesh membrane support that supports the permeable membrane and has a barrier that prevents intermetallic diffusion bonding.

2. Description of the Invention Background

Generally, when separating a gas from a mixture of gases by diffusion, the gas mixture is typically brought into contact with a nonporous membrane which is selectively permeable to the gas that is desired to be separated from the gas mixture. The desired gas diffuses through the permeable membrane and is separated from the other gas mixture. A pressure differential between opposite sides of the permeable membrane is usually created such that the diffusion process proceeds more effectively, wherein a higher partial pressure of the gas to be separated is maintained on the gas mixture side of the permeable membrane. It is also desireable for the gas mixture and the selectively permeable membrane to be maintained at elevated temperatures to facilitate the separation of the desired gas from the gas mixture. This type of process can be used to separate hydrogen from a gas mixture containing hydrogen. Thus, in this application, the permeable membrane is permeable to hydrogen and is commonly constructed from palladium or a palladium alloy. The exposure to high temperatures and mechanical stresses created by the pressure differential dictates that the permeable membrane be supported in such a way that does not obstruct passage of the desired gas through the membrane.

One type of conventional apparatus used for the separation of hydrogen from a gas mixture employs a woven refractory-type cloth for supporting the permeable membrane during the separation process. The disadvantage of this type of conventional membrane support is that the cloth support is susceptible to failure when it is exposed to high mechanical stresses associated with the differential pressure required to effect diffusion through the membrane material.

Another conventional permeable membrane support is a metal gauze structure placed adjacent to the permeable membrane. The disadvantage of this type of support is that intermetallic diffusion bonding occurs between the membrane support and the permeable membrane when they are exposed to high pressures and high temperatures. The high pressure tends to compress the permeable membrane and the metal gauze together and the high temperatures tend to deteriorate the chemical bonds of those materials. Such undesirable condition results in migration of the molecules of the permeable membrane to the metal gauze membrane and the migration of molecules of the metal gauze membrane to the permeable membrane until a bond is formed between those two structures. This intermetallic diffusion bonding results in a composite material that is no longer permeable by the hydrogen gas.

Thus, the need exists for a method and apparatus for separating a desired fluid from a fluid mixture that can reliably withstand high operating pressures and temperatures.

Another need exists for a permeable membrane and support arrangement for separating a desired fluid from a fluid mixture, wherein the permeable membrane is not susceptible to breakage or intermetallic diffusion bonding.

Yet another need exists for a method of supporting a membrane that is permeable to a fluid, wherein the fluid permeable membrane is exposed to high temperatures and high pressures.

SUMMARY OF THE PRESENT INVENTION

The present invention provides a fluid separation assembly having a fluid permeable membrane and a wire mesh membrane support adjacent the fluid permeable membrane, wherein the wire mesh membrane support has an intermetallic diffusion bonding barrier.

The present invention further provides a method for separating a desired fluid from a fluid mixture comprising a membrane that is permeable by the desired fluid, providing a wire mesh membrane support with a intermetallic diffusion bonding barrier, wherein the wire mesh membrane support is adjacent to the fluid permeable membrane, contacting the fluid permeable membrane support with the fluid mixture and contacting the wire mesh membrane support with the desired fluid permeating the fluid permeable membrane.

The present invention further provides for a method of making a fluid separation assembly comprising providing a membrane permeable to a desired fluid, providing a first retainer, providing a wire mesh membrane support having an intermetallic diffusion bonding barrier and placing it adjacent the fluid permeable membrane, providing a permeate member adjacent the wire mesh membrane support, providing a gasket adjacent the fluid permeable membrane, providing a second retainer adjacent the wire mesh membrane support and joining the first retainer, the gasket and the second retainer at their peripheries.

The present invention provides for a method for supporting a fluid permeable membrane comprising providing a membrane that is permeable by a desired fluid, and providing a wire mesh membrane support with an intermetallic diffusion bonding

barrier, wherein the wire mesh membrane support is adjacent and supports the fluid permeable membrane.

Other details, objects and advantages of the present invention will become more apparent with the following description of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

For the present invention to be readily understood and practiced, preferred embodiments will be described in conjunction with the following figures wherein:

FIG. 1 is a top isometric view of a fluid separation assembly of the present invention;

FIG. 2 is an exploded isometric view of the fluid separation assembly of the present invention shown in FIG. 1;

FIG. 3 is an exploded isometric view of the female permeable membrane subassembly of the present invention shown in FIG. 1;

FIG. 4 is an exploded isometric view of the male permeable membrane subassembly of the present invention shown in FIG. 1;

FIG. 5 is a sectional isometric view of the fluid separation assembly of the present invention;

FIG. 6 is an enlarged view of section A of the fluid separation assembly shown in FIG. 5;

FIG. 7 is a cross-sectional view of the fluid separation assembly of the present invention shown in FIG. 1 taken along line 7-7;

FIG. 8 is an isometric sectional diagrammatical view of a module employing several fluid separation assemblies of the present invention; and

FIG. 9 is an enlarged section **B** of the module shown in FIG. 8.

DETAILED DESCRIPTION OF THE INVENTION

The present invention will be described below in terms of apparatuses and methods for separation of hydrogen from a mixture of gases. It should be noted that describing the present invention in terms of a hydrogen separation assembly is for illustrative purposes and the advantages of the present invention may be realized using other structures and technologies that have a need for such apparatuses and methods for separation of a desired fluid from a fluid mixture containing the desired fluid.

It is to be further understood that the Figures and descriptions of the present invention have been simplified to illustrate elements that are relevant for a clear understanding of the present invention, while eliminating, for purposes of clarity, other elements and/or descriptions thereof found in a hydrogen separation assembly. Those of ordinary skill in the art will recognize that other elements may be desirable in order to implement the present invention. However, because such elements are well known in the art, and because they do not facilitate a better understanding of the present invention, a discussion of such elements is not provided herein.

FIGS. 1 and 2 illustrate one embodiment of the fluid separation assembly 10 of the present invention, wherein FIG. 2 is an exploded view of the fluid separation assembly 10 shown in FIG. 1. The fluid separation assembly 10 comprises first membrane retainers 12, a female membrane subassembly 14, a first membrane gasket 16, a first wire mesh membrane support 18, second membrane retainers 20, a slotted permeate plate 22, a permeate rim 24, a second wire mesh membrane support 28, a second membrane gasket 30 and a male membrane subassembly 32. In one

embodiment, the first retainers 12 may be substantially flat ring members having an outside diameter equal to the diameter of the female and male membrane subassemblies 14 and 32 and a thickness of between approximately 0.001 inches and 0.060 inches. The first membrane retainers 12 each have a centrally disposed opening 13 and 35. The first membrane retainers 12 may be made from Monel 400 (UNS N 04400); however, other materials that are compatible with the welding process, discussed below, may also be used. It will also be appreciated that while first retainers 12 are shown as comprising substantially annular members they may have other desired shapes and other thicknesses without departing from the spirit and scope of the present invention.

FIG. 3 is an exploded view of a female permeable membrane subassembly 14. In this embodiment, female membrane subassembly 14, comprises a female gasket seat 36, a hydrogen permeable membrane 38, an inner diameter membrane gasket 40 and a center support washer 42. In this embodiment, the female gasket seat 36 is a substantially flat ring member 44 having a raised face 46 extending around the ring member 44 and a centrally disposed opening 45. It will be appreciated that while this embodiment is shown with gasket seats with this configuration, there may be other geometries of gasket seats specific to other gasket configurations or materials that may be used without departing from the spirit and the scope of the present invention. The female gasket seat 36 may be made from Monel 400; however, other materials such as nickel, copper, nickel alloys, copper alloys, or other alloys that provide for compatible fusion with the chosen permeable membrane material during welding may be used. In this embodiment, the hydrogen permeable membrane 38 is a substantially planar member having a circular configuration, opposing sides 48 and a centrally

disposed circular opening 50. The inner diameter membrane gasket 40 is also a flat ring member having a centrally disposed opening 51. Also in this embodiment, the inner diameter membrane gasket 40 may be made from Monel 400 (UNS N 04400); however, other materials such as nickel, copper, nickel alloys, copper alloys, or other alloys that provide for compatible fusion with the chosen permeable membrane material during welding may be used. The center support washer 42 is a flat ring member having a centrally disposed opening 53. The center support washer 42 may be made of Monel 400 (UNS N 04400); however, other materials such as nickel, copper, nickel alloys, copper alloys, or other alloys that provide for compatible fusion with the chosen permeable membrane material or alloy during welding may be used.

Referring back to FIG. 2, in this embodiment, the first and second membrane gaskets 16 and 30 are each a substantially flat ring member having a centrally-disposed opening 55 and 57, respectively. In this embodiment, the first and second membrane gaskets 16 and 30 may be made from Monel 400 alloy (UNS N 004400), nickel, copper, nickel alloys, copper alloys or other precious alloys or other alloys compatible with the weld that is used to join the components of the fluid separation assembly 10 and which is discussed below. The first and second membrane gaskets 16 and 30 may have a thickness of between approximately 0.0005 inches to 0.005 inches. However, other gasket thicknesses could be employed.

Also in this embodiment, the first and second wire mesh membrane supports 18 and 28 are planar, ring-shaped members having centrally disposed openings 52 and 54, respectively. The wire mesh membrane supports 18 and 28 may be made from 316L stainless steel alloy with a mesh count of between approximately 19 to 1,000 mesh per inch, wherein the mesh count is chosen to be adequate to support the

hydrogen permeable membranes 38 and 62. The style of woven mesh may include a standard plain square weave, twill square weave, rectangular plain or twill weave or triangular plain or twill weave. One example of a mesh count that may be used is 49 mesh per inch. The wire mesh membrane supports 18 and 28 may be made of steel alloys, stainless steel alloys, nickel alloys or copper alloys. The wire mesh may be coated with a thin film that prevents intermetallic diffusion bonding (i.e., an intermetallic diffusion bonding barrier). The intermetallic diffusion bonding barrier may be a thin film containing at least one of an oxide, a nitride, a boride, a silicide, a carbide, or an aluminide and may be applied using a number of conventional methods, including but not limited to, physical vapor deposition (PVD), chemical vapor disposition, and plasma enhanced vapor deposition. For example, the method of reactive sputtering, a form of PVD, can be used to apply a thin oxide film of between approximately 600-700 angstroms to the wire mesh membrane supports 18 and 28. A variety of oxides, nitrides, borides, silicides, carbides and aluminides may also be used for the thin film as well as any thin films that will be apparent to those of ordinary skill in the art. Using this form of PVD results in a dense amorphous thin film having approximately the same mechanical strength as the bulk thin film material.

Also in this embodiment, the second membrane retainers 20 each are a substantially flat ring member. One retainer 20 has a centrally disposed opening 59 and retainer 20 has a centrally disposed opening 61. See FIG. 2. These retainers 20 may be the same thickness as the first and second wire mesh membrane supports 18 and 28. The second membrane retainers 20 may be made from a material that is compatible with the weld, discussed below, such as Monel 400 (UNS N 004400) and

nickel, copper, nickel alloys, copper alloys, precious metals or alloys, or other alloys that provide for compatible fusion with the chosen membrane material or alloy during welding may be used.

In this embodiment, the slotted permeate plate 22 is a steel plate having a plurality of slots 56 extending radially and outwardly from a central opening 58 in the direction of the periphery of the slotted permeate plate 22. The number of slots 56 in a slotted permeate plate 22 may range from approximately 10 to 72. However, other suitable slot densities could conceivably be employed. The permeate plate rim 24 is a substantially flat ring member having a centrally disposed opening 63 and an inner diameter larger than the outer diameter of the slotted permeate plate 22. The permeate plate rim 24 is made from Monel 400 (UNS N 04400); however, other materials can also be used such as nickel, copper, nickel alloys, copper alloys, precious metals or alloys or other alloys that provide for compatible fusion with the chosen membrane material or alloy during welding.

FIG. 4 is an exploded view of the male permeable membrane subassembly 32. The male membrane subassembly 32 comprises a male gasket seat 60, a hydrogen permeable membrane 62, an inner diameter membrane gasket 64, and a center support washer 66. The hydrogen permeable membranes 38 and 62 may be made from at least one hydrogen permeable metal or an alloy containing at least one hydrogen permeable metal, preferably selected from the transition metals of groups VIIB or VIIB of the Periodic Table. The hydrogen permeable membrane 62, the inner diameter membrane gasket 64, and the center support washer 66 are similar in structure to the hydrogen permeable membrane 38, the inner diameter membrane gasket 40 and the center support washer 42, respectively, discussed above. The male

gasket seat 60 is a substantially planar ring member 68 having a circular protuberance 70 extending around a centrally disposed opening 72. In this embodiment, the female gasket seat 36 and the male gasket seat 60 are made of a high strength alloy material that is compatible with the weld such as Monel 400. The inner diameter member gaskets 40 and 64 are made from the same materials as the first and second outer diameter membrane gaskets 16 and 30, discussed above.

FIGS. 5 through 7 are various cross-sectional views of the assembled fluid separation assembly 10 of the present invention, wherein FIG. 6 is an enlarged view of section A of the fluid separation assembly 10 shown in FIG. 5, and FIG. 7 is a cross-sectional plan view of the assembled fluid separation assembly 10. When assembling the components of the fluid separation assembly 10 shown in FIGS. 2-4, the female membrane subassembly 14 and the male membrane subassembly 32 are initially assembled. The female gasket seat 36, the permeable membrane 38, the inner diameter membrane gasket 40 and the center support washer 42 are placed adjacent one another, as shown in FIG. 7, such that their central disposed openings 45, 50, 51 and 53, respectively, are coaxially aligned. A first weld 71, shown in FIG. 7, is placed at the openings thereof. The first weld 71 takes the form of a weld bead creating a hermetic seal between the female gasket seat 36, the permeable membrane 38, the inner diameter membrane gasket 40 and the center support washer 42. The weld 71 can be effected by a number of commercially available technologies, including but not limited to, lasers, electron beam and tungsten inert gas (TIG) welding. Alternative joining technologies such as brazing or soldering may also be employed with the desired result being a gas tight bond between the gasket seat 36 and the permeable membrane 38. Likewise, the components of the male membrane subassembly 32,

which include the male gasket seat 60, the permeable membrane 62, the inner diameter membrane gasket 66 and the center support washer 66 are also placed adjacent one another, as shown in FIG. 7, such that their centrally disposed openings 72, 81, 83 and 85 are coaxidly aligned with each other and a second weld bead 73, shown in FIG. 7, is placed around the circumference of the openings 72, 81, 83 and 85 thereof. As stated above, the weld 73 can be effected by a number of commercially available technologies, including but not limited to, laser, electron beam, and tungsten inert gas (TIG) welding.

After the components of the female membrane subassembly 14 and the components of the male membrane subassembly 32 have each been connected by the welds 71 and 73, respectively, they are assembled with the other components described above to form the fluid separation assembly 10. As shown in FIG. 2, the first and second retainer members 12 and 20, the female and male membrane subassemblies 14 and 32, the first and second outer diameter gaskets 16 and 30, the first and second wire mesh membrane supports 18 and 28, the slotted permeate plate 22 and the permeate rim 24 are aligned such that their centrally disposed openings are coaxially aligned. As shown in FIG. 7, these components are retained in that configuration by placing a weld 74 at the outer periphery of the first and second retainer members 12 and 20, the female and male membrane subassemblies 14 and 32, the first and second outer diameter membrane gaskets 16 and 30, and the slotted permeate rim 24. Alternatively, these parts could be assembled such that their centrally disposed openings are coaxially aligned, as shown in FIG. 7, and connected to one another by performing a brazing or soldering operation at the outer periphery of the first and second retainer members 12 and 20, the female and male membrane

subassemblies 14 and 32, the first and second outer diameter membrane gaskets 16 and 30 and the slotted permeate rim 24. As seen in FIG. 6, a space 75 is provided between the slotted permeate plate 22 and the permeate rim 24 which permits expansion and contraction of the components of the fluid separation assembly 10 resulting from the change in temperature. Assembled, the fluid separation assembly 10 may have a thickness ranging from 0.010 inches to 0.125 inches, depending upon the thicknesses of the components employed.

When separating the hydrogen from a mixture of gas that includes hydrogen, the gas mixture is directed towards the permeable membranes 38 and 62 of the female membrane subassembly 14 and the male membrane subassembly 32, respectively, in the directions **D** and **E**, as shown in FIG. 7. For clarity, the permeable membranes 38 and 64 of the female and male membrane subassemblies 14 and 32, respectively are shown in FIG. 7 as being spaced from the first and second wire mesh membrane supports 18 and 28; however, in use, the permeable membranes 38 and 62 are in contact with the first and second wire mesh membrane supports 18 and 28 and are supported thereby. When the gas mixture containing hydrogen contacts the hydrogen permeable membranes 38 and 62, the hydrogen permeates through the permeable membranes 38 and 62, passes through the first and second wire mesh membrane supports 18 and 28 and enters the slotted permeate plate 22 where the hydrogen enters a specific slot 56 and to be directed toward the central axis **C** by the passageways formed by the slots 56. The central openings of the components of the fluid separation assembly 10, shown in FIG. 2, form a conduit 80 wherein the purified hydrogen is collected and transported to a desired location. The conduit 80 may have a diameter of between approximately 0.25 inches and 1 inch. The diameter is

determined by the components of the fluid separation assembly 10 and by the desire that the hydrogen flow be substantially unimpeded. The non-hydrogen gases in the gas mixture are prevented from entering the fluid separation assembly 10 by the fluid permeable membranes 38 and 62. The remainder of the hydrogen depleted gas mixture is directed around the exterior of the fluid separation assembly 10 in this embodiment.

FIGS. 8 and 9 illustrate a module 85 employing several fluid separation assemblies 10 of the present invention, wherein FIG. 9 is an enlarged section **B** of the module 85. Each of the fluid separation assemblies 10 are shown as a solid body for clarity. However, each of the fluid separation assemblies 10 are the same as the fluid separation assemblies 10 shown in FIGS. 1-7. The module 85 has a feed gas inlet 91, a permeate outlet 90 and a discharge gas outlet 93. The fluid separation assemblies 10 are coaxially aligned. Distribution plates 87 are sandwiched between and separate the fluid separation assemblies 10. The distribution plates 87 are positioned on a shoulder of the gasket seats 36 in such a manner that they are positioned equidistant from the planar surface of the permeable membrane assemblies 14 and 32 in successive fluid separation assemblies 10. The distribution plates 87 are not fixedly connected to the gasket seats 36 and 60, but rather rest on a shoulder of the gasket seat 36. There is sufficient clearance between the central opening of the redistribution plate 87 and the shoulder on the female gasket seat 36 that the redistribution plates 87 and the fluid separation assemblies 10 are allowed to position themselves inside the wall of the membrane housing independently of the position of the fluid separation assemblies 10. Each distribution plate 87 has openings 89 therein. The fluid separation assemblies 10 are aligned one with the other such that each of the conduits 80 of the

fluid separation assemblies 10 form a larger conduit 90. The path of the gas mixture containing hydrogen, represented by arrow **G**, enters the opening 89 and travels along the outer surface of the fluid separation assembly 10, wherein some of the hydrogen of the gas mixture is free to enter the fluid separation assembly 10 by the permeable membranes 38 and 62 and is directed along path **F** into the larger conduit 90 and the remaining gas mixture follows arrow **G** and serpentines through the passageway, formed by the distribution plates 87, the fluid separation assemblies 10 and the interior wall 92 of the module 85. As the gas mixture travels through the passageway, it contacts the outer surfaces of several other fluid separation assemblies 10, wherein more of the hydrogen remaining in the gas mixture permeates the permeable membrane 38 and 62 and follows the path **F** resulting in this purified hydrogen entering the larger conduit 90. The remainder of the hydrogen depleted gas mixture exits through a port 93 located at the opposite end of the module 85 after flowing over the entire stack of fluid separation membrane assemblies 10.

Although the present invention has been described in conjunction with the above described embodiments thereof, it is expected that many modifications and variations will be developed. This disclosure and the following claims are intended to cover all such modifications and variations.

What is claimed is:

1. A fluid separation assembly, comprising:

a fluid permeable membrane; and

a wire mesh membrane adjacent said fluid permeable membrane, said wire mesh membrane having an intermetallic diffusion barrier.

2. The fluid separation assembly according to claim 1, wherein said barrier is a thin film containing at least one of one of the group consisting of nitrides, oxides, borides, silicides, carbides and aluminides.

3. The fluid separation assembly according to claim 2, wherein said barrier is a thin film containing one of an oxide and a nitride.

4. The fluid separation assembly according to claim 1, wherein said wire mesh membrane is in contact with said fluid permeable membrane.

5. The fluid separation assembly according to claim 1, wherein said fluid permeable membrane is a substantially planar member having a centrally disposed opening.

6. The fluid separation assembly according to claim 5, wherein said wire mesh membrane is a substantially planar membrane having a centrally disposed opening which is in alignment with said fluid permeable membrane opening.

7. The fluid separation assembly according to claim 6, wherein said wire mesh membrane has a mesh count ranging between approximately 19 to 1000 mesh per inch.

8. The fluid separation assembly according to claim 6, further comprising a slotted permeate plate adjacent to said wire mesh membrane.

9. The fluid separation assembly according to claim 8, further comprising a second fluid permeable membrane and a second wire mesh membrane, wherein said slotted permeate plate has a first side and a second side and said first permeable membrane is adjacent said first side of said slotted permeate plate and said first wire mesh membrane is adjacent said first permeable membrane, and wherein said second wire mesh membrane is adjacent said slotted permeate plate second side and said second fluid permeable membrane is adjacent said second wire mesh membrane.

10. The fluid separation assembly according to claim 9, wherein said slotted permeate plate, said second wire mesh membrane and said second fluid permeable membrane each also have a centrally disposed opening and each of said centrally disposed openings are coaxially aligned and form a central conduit.

11. The fluid separation assembly according to claim 1, wherein said wire mesh membrane is made from stainless steel.

12. The fluid separation assembly according to claim 9, wherein each of said fluid permeable membranes further comprises a gasket seat, a membrane gasket, and a washer to form a first and second membrane subassembly, wherein said gasket seats, said membrane gaskets and said washers are connected to said fluid permeable membranes.

13. The fluid separation assembly according to claim 12, further comprising a weld bead connected to each of said first and second membrane subassemblies.

14. The fluid separation assembly according to claim 13, further comprising first retainers, one of said first retainers connected to each of said fluid permeable membranes.

15. The fluid separation assembly according to claim 13, further comprising second retainers adjacent said slotted permeate plate.

16. The fluid separation assembly according to claim 13, further comprising first retainers, one of said second retainers adjacent each of said fluid permeable membranes.

17. The fluid separation assembly according to claim 13, further comprising gaskets, one of said gaskets adjacent each of said wire mesh membranes.

18. A fluid separation assembly, comprising:

a slotted permeate having opposing faces;

first and second wire mesh membranes, each of said wire mesh membranes having a first surface and a second surface, wherein each of said wire mesh membranes first surfaces are adjacent said slotted permeate;

first and second membranes permeable to a desired fluid, each of said permeable membranes adjacent one of said wire mesh membranes second surfaces;

a permeate rim surrounding said slotted permeate;

first retainers adjacent each of said permeable membranes;

second retainers adjacent said slotted permeate and said wire mesh membranes; and

gaskets between each of said wire mesh membranes and said permeable membranes, wherein said permeate rim, said first retainers, said second retainers said permeable membranes and said gaskets are joined together at their peripheries.

19. The fluid separation assembly according to claim 18, wherein said permeate rim, said first retainers, said second retainers, said permeable membranes and said gaskets are jointed together by a weld bead at their peripheries.

20. The fluid separation assembly according to claim 18, further comprising a female gasket seat, a membrane gasket and a washer, wherein said female gasket seat, said membrane gasket and said washer are connected to one of said permeable membranes and comprise a female membrane subassembly.

21. The fluid separation assembly according to claim 20, further comprising a male gasket seat, a second membrane gasket, and a second washer, wherein said male gasket seat, said second membrane gasket and said second washer are connected to the other of said fluid permeable membranes and comprises a male membrane subassembly.

22. The fluid separation assembly according to claim 21, wherein each of said gasket seats, said membrane gaskets, said washers and said permeable membranes have a centrally disposed opening and said openings are coaxially aligned and first and second weld beads connect the components of each subassembly.

23. The fluid separation assembly according to claim 18, wherein each of said two wire mesh membranes have an intermetallic diffusion bonding barrier.

24. The fluid separation assembly according to claim 23, wherein said intermetallic diffusion bonding barrier is a thin film containing at least one of the group consisting of oxides, nitrides, borides, silicides, carbides and aliminides.

25. The fluid separation assembly according to claim 18, wherein said first retainers, said second retainers, said gaskets, said permeate rim and said two membranes are connected at their peripheries.

26. The fluid separation assembly according to claim 25, wherein a weld bead is located at said peripheries of each of said first retainers, said second retainers, said gaskets, said permeate rim and said two membranes.

27. The fluid separation assembly according to claim 18, wherein each of said two wire mesh membranes are stainless steel.

28. The fluid separation assembly according to claim 18, wherein each of said two wire mesh membranes have mesh counts ranging from approximately 19 to 1000 mesh per inch.

29. The fluid separation assembly according to claim 28, wherein each of said two wire mesh membranes have mesh counts ranging from 49 to 1000 mesh per inch.

30. The fluid separation assembly according to claim 26, wherein each of said permeable membranes and said slotted permeate have a centrally disposed opening that form a conduit.

31. A fluid separation module, comprising:

a plurality of fluid separation assemblies, wherein each of said fluid separation assemblies comprises:

a slotted permeate having opposing faces;

first and second wire mesh membranes, each of said wire mesh membranes having a first surface and a second surface, wherein each of said wire mesh membranes first surfaces is adjacent said slotted permeate;

first and second membranes permeable to a desired fluid, each of said permeable membranes adjacent one of said wire mesh membranes second surfaces;

a permeate rim surrounding said slotted permeate;

first retainers adjacent each of said permeable membranes;

second retainers between said slotted permeate and each of said wire mesh membranes; and

gaskets between each of said wire mesh membranes and permeable membranes, wherein said permeate rim, said first retainers, said second retainers and said gaskets are joined together at their peripheries.

32. A method for separating a desired fluid from a fluid mixture, comprising:

providing a membrane that is permeable by the desired fluid and having opposing surfaces;

providing a wire mesh membrane with an intermetallic diffusion bonding barrier, wherein the wire mesh membrane is adjacent to one of the opposing surfaces of the fluid permeable membrane;

contacting the fluid permeable membrane with the fluid mixture; and

contacting the wire mesh membrane with the desired fluid permeating the fluid permeable membrane.

33. The method according to claim 32, further comprising:

forming the barrier from a thin film containing at least one of the group consisting of oxides, nitrides, borides, silicides, carbides and aluminides.

34. The method according to claim 33, further comprising:

forming the wire mesh membrane from a stainless steel screen having a mesh count ranging from approximately 19 to 1000 counts per inch.

35. A method of making a fluid separation assembly, comprising:

providing a membrane permeable to a desired fluid and having opposing surfaces;

providing a first retainer adjacent to one of the opposing surfaces of the fluid permeable membrane;

providing a wire mesh membrane having an intermetallic diffusion bonding barrier and adjacent to the other one of the opposing surfaces of the fluid permeable membrane;

providing a permeate member adjacent the wire mesh membrane;

providing a gasket between the fluid permeable membrane and the wire mesh membrane, wherein the periphery of the gasket extends beyond the periphery of the wire mesh membrane;

providing a second retainer between the gasket and the permeate plate; and

hermetically sealing the first retainer, the gasket and the second retainer at their peripheries.

36. The method according to claim 35, further comprising:

forming the barrier from a thin film containing at least one of the group consisting of oxides, borides, silicides, aluminides and nitrides.

37. The method according to claim 35, further comprising:

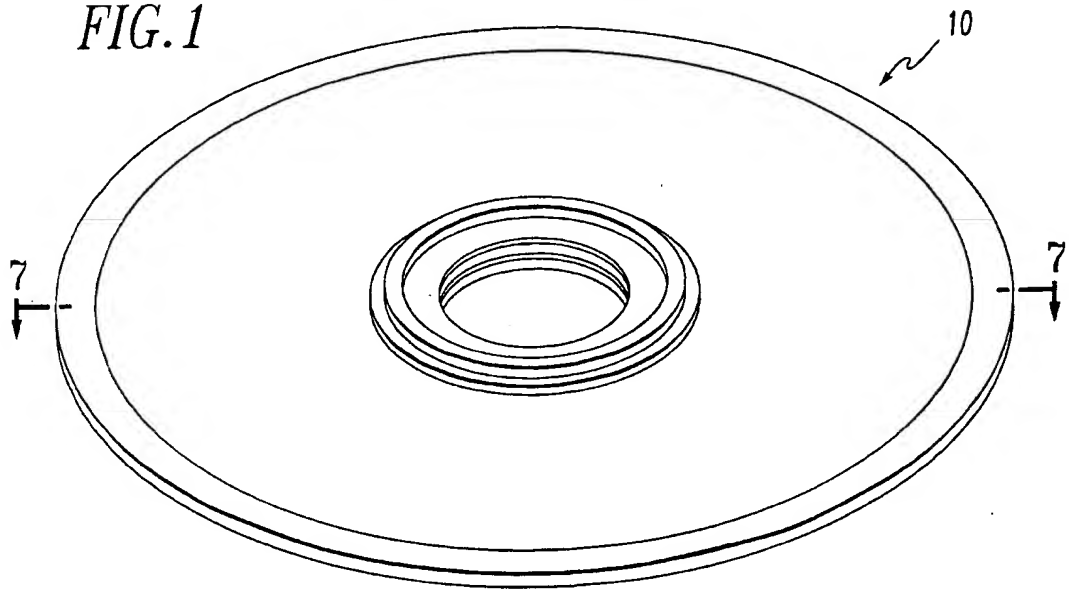
forming the wire mesh membrane from a stainless steel screen with a mesh count ranging from 19 to 1000 mesh per inch.

38. A method for supporting a fluid permeable membrane, comprising:

providing a membrane that is permeable by a desired fluid and having opposing surfaces; and

providing a wire mesh membrane with an intermetallic diffusion bonding barrier, wherein the wire mesh membrane is adjacent to one of the opposing surfaces of the fluid permeable membrane.

FIG. 1



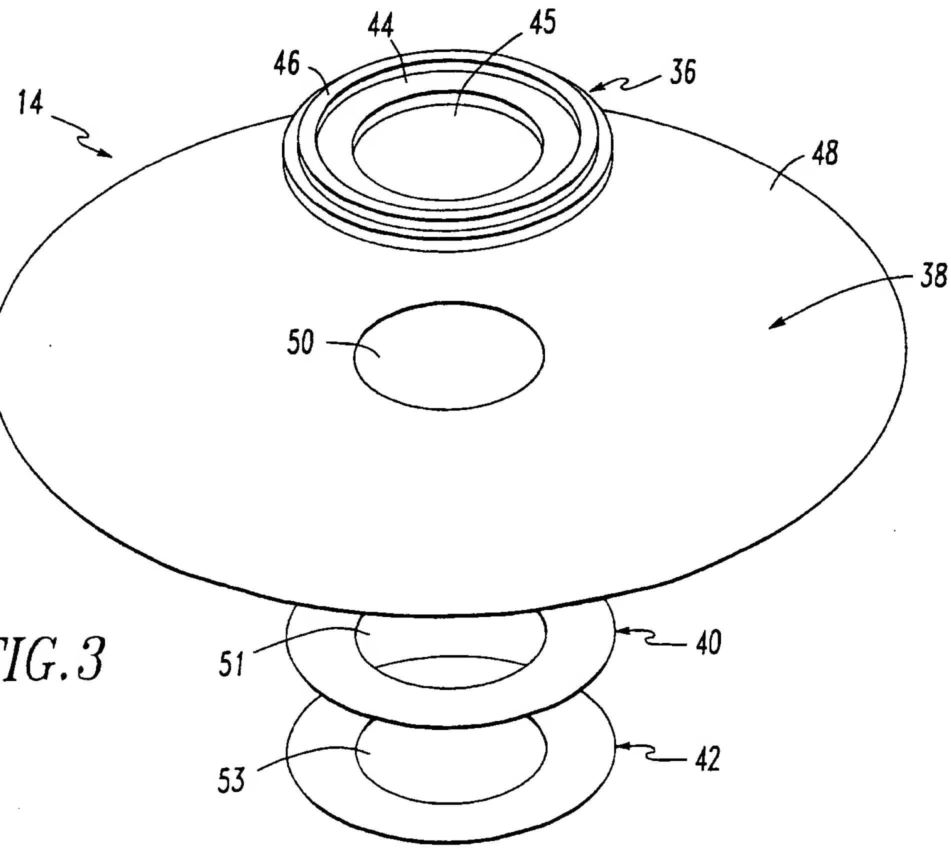


FIG. 3

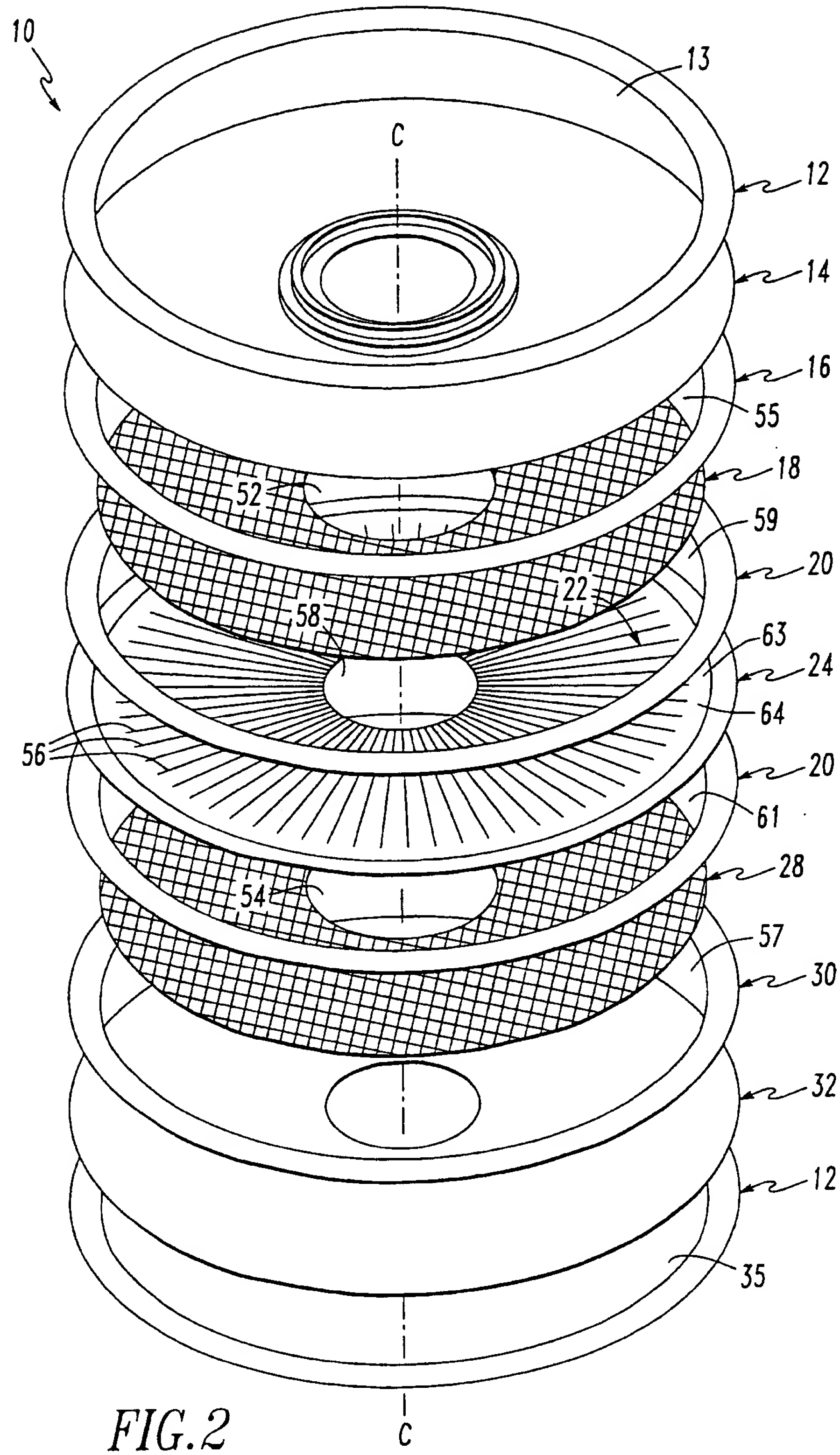

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FIG.2

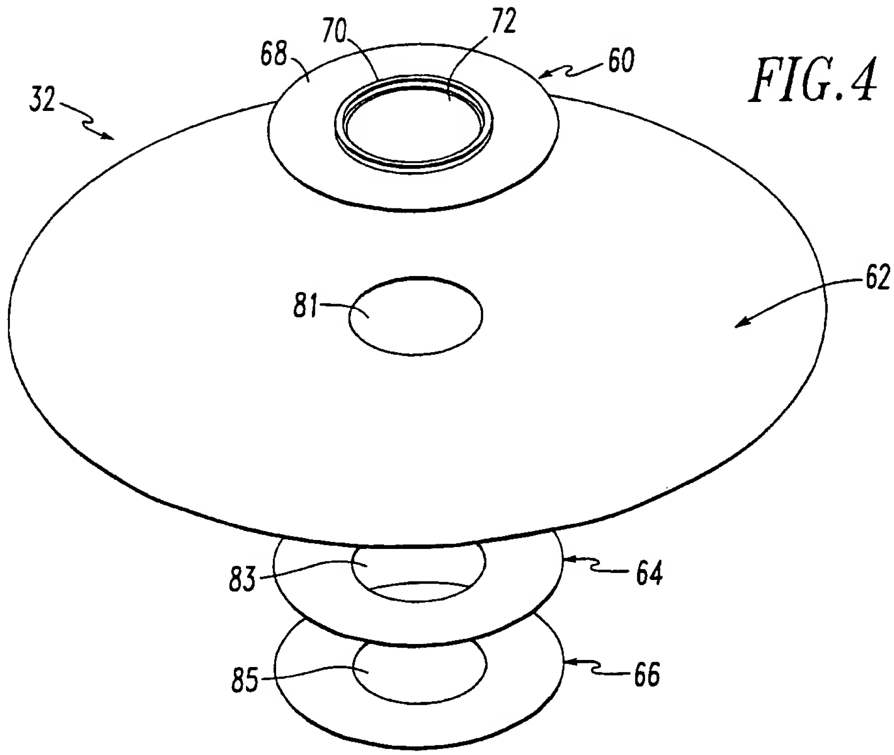

FIG.4

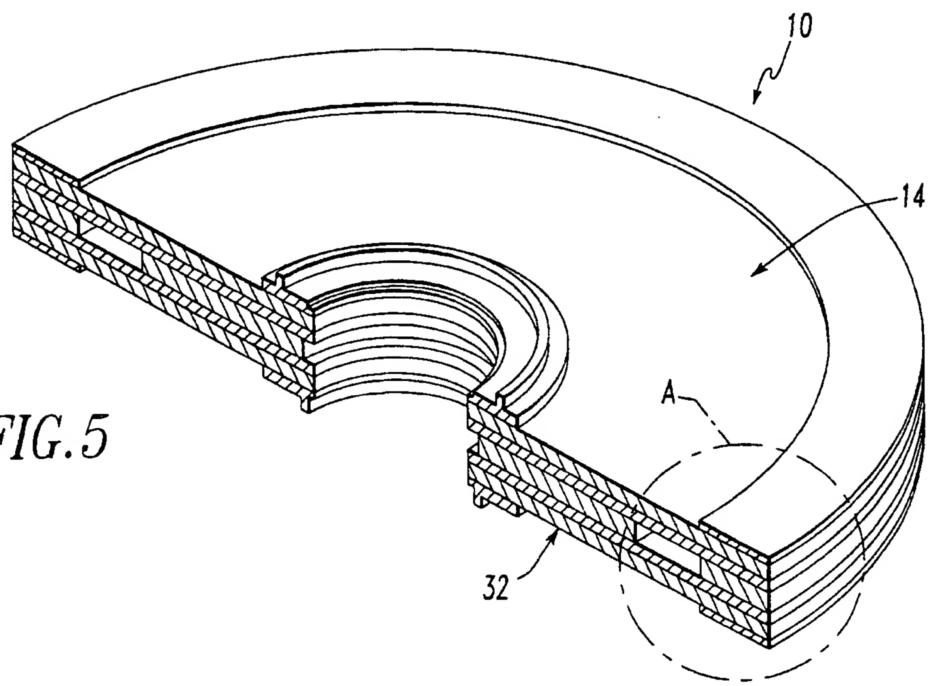

FIG.5

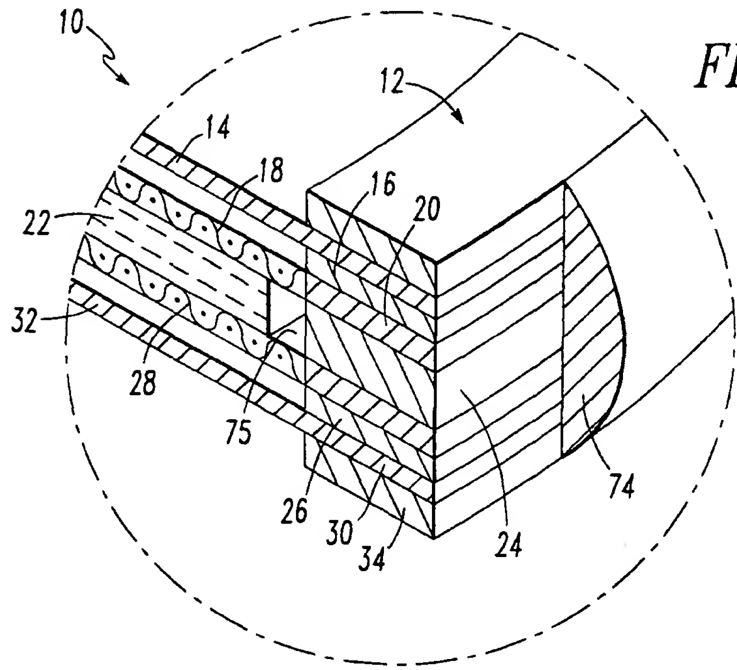
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FIG. 6

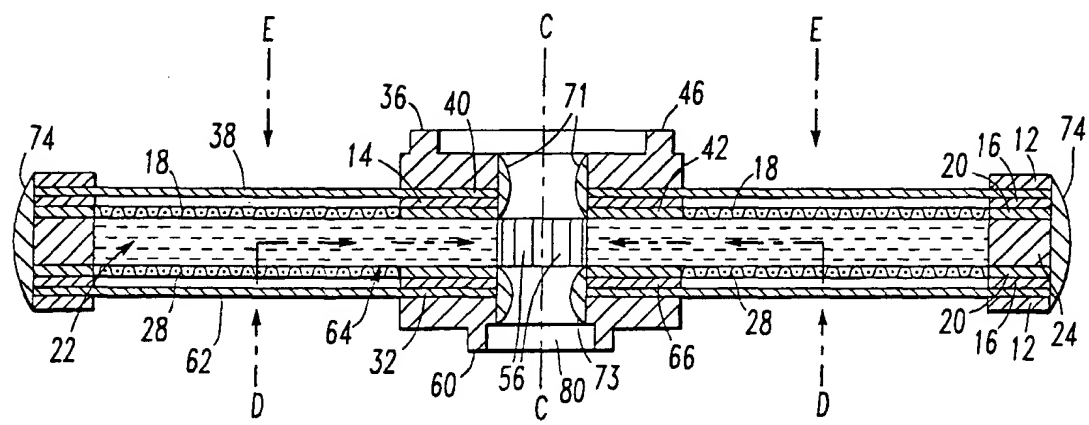
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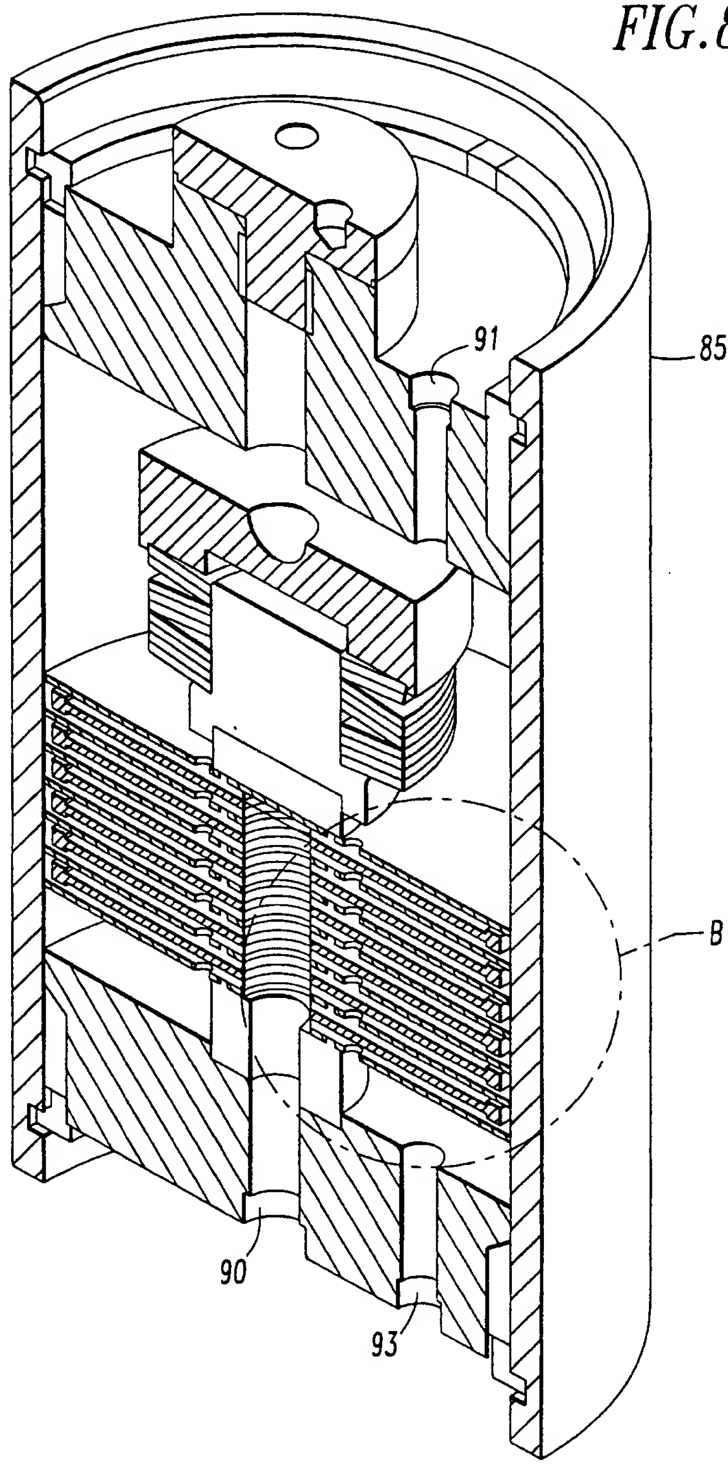
FIG. 7

FIG.8



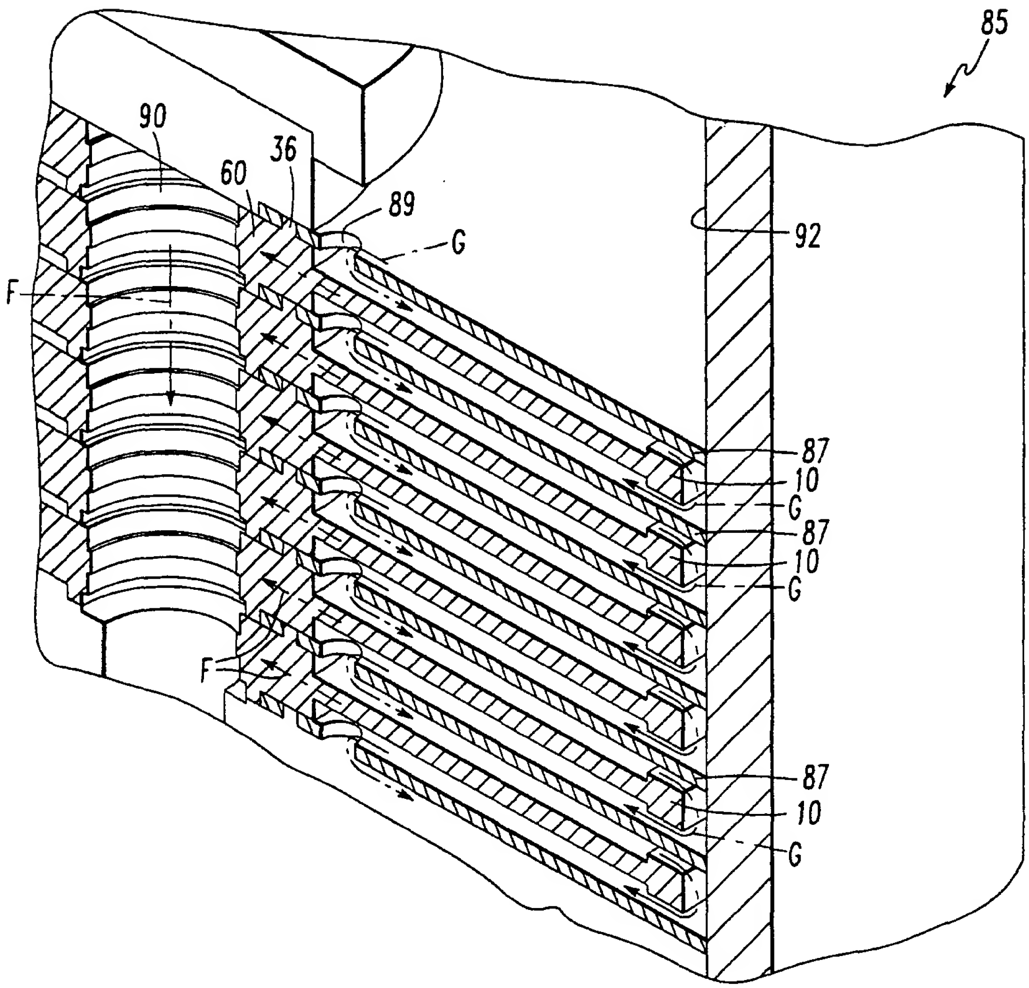


FIG.9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/28591

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :B01D 53/22
US CL :95/56; 96/11; 210/321.84
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 95/55, 56; 96/4, 7, 9, 11; 210/321.75, 321.84

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 5,645,626 A (EDLUND ET AL) 08 July 1997 (08.07.97) Figs. 3-6, col. 5, line 23 through col. 6, line 24, col. 7, line 36 through col. 15, line 63.	1-6, 8, 11, 32-33, 35-36, 38 --------- 7, 9-10, 12-31, 34, 37
Y	US 4,699,637 A (INIOTAKIS ET AL) 13 October 1987 (13.10.87) col. 2, lines 22-28.	7, 28-29, 34, 37
Y	US 3,486,301 A (BONNET) 30 December 1969, (30.12.69) col. 2, line 35 through col. 3, line 34.	9-10, 12- 27, 30-31
A	US 3,336,730 A (MCBRIDE ET AL) 22 August 1967 (22.08.67).	1-38

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

30 NOVEMBER 2000

Date of mailing of the international search report

17 JAN 2001

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/28591

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,126,045 A (KOHLHEB ET AL) 30 June 1992 (30.06.92).	1-38
A	US 5,217,506 A (EDLUND ET AL) 08 June 1993 (08.06.93).	1-38
A	US 5,225,080 A (KARBACHSCH ET AL.) 06 July 1993 (06.07.93).	1-38
A	US 5,269,917 A (STANKOWSKI) 14 December 1993 (14.12.93).	1-38